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BLACK-KNOT

OF

Plums and Cherries, and Methods of Treatment.

By E. G. LODEMAN.

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CORNELL UNIVERSITY, ITHACA, N. Y., December 15, 1894.

THE HONORABLE COMMISSIONER OF AGRICULTURE, ALBANY,

Sir:—The following account of the black-knot of plums and cherries is submitted for publication and distribution under section 87, chapter 675, of the laws of 1894. The subject is an important one to all fruit growers, and the present account contains the first experimental proof that the disease can be kept in check by spraying. The leading points established in this paper are these: The disease usually shows itself the year following inoculation, a fact which is proved by the absence of knots on the growth of the season; the inoculation occurs mostly in crotches and at the junctures of the annual growths, owing to the greater frequency of chinks at these places, and to more tender bark, and to convenient places for lodgement of the spores; if the branches are constantly covered with fungicide, the germinating spores are killed. Good Bordeaux mixture remains upon the branches a long time, and it appears to retain its efficacy from the fact that when applications ceased early in June the summer spores of the fungus, which no doubt appeared after this time, were apparently unable to seriously multiply the disease. Whilst the results with the spray are surprising, there is nevertheless every reason for anticipating them, for it is evident that the infection takes place from spores falling upon the plant, and it is generally understood that germinating spores are killed by copper fungicides. Mr. Lodeman's results with the black-knot are supplemented by similar results obtained by myself upon another fungus which enters the deep tissues, the red rust of the quince (see Bulletin 80).

L. H. BAILEY.

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THE BLACK-KNOT OF PLUMS AND CHERRIES, AND METHODS OF TREATMENT.

Distribution—Many of our stone fruits, both the wild and the cultivated forms, suffer from the attacks of a disease which is popularly known as the black-knot. It is of American origin, and from the early records of its presence on cultivated trees, it appears to have been particularly abundant along the northern half of our Atlantic sea-board. This may be ascribed to the fact that this portion of the country was first most thickly settled and consequently such a trouble would there be first noted. In the early part of this century, however, the disease had become more serious in most of the regions in which it was first mentioned, and the ruinous effects of its presence gradually became known in those sections which appear to have been free from the trouble at the time the first settlements were made. It is not improbable that the disease was first restricted to the country east of the Alleghany mountains, although several of the plants upon which it is found are native in the regions to the west. It appears that no serious damage was done by the fungus in western orchards until the number of its cultivated host plants had become sufficiently great to allow of the rapid propagation and spread of the disease. In some cases its presence could be traced directly to an eastern source.

In *The Cultivator*, for 1850, page 333, is the note that "Benjamin Hodge, of Buffalo, N. Y., who has raised and sold trees for the past 30 years says he never had this malady among his plum trees till the present season, and that in the instance cited it was introduced from the east." He further claimed that all the affected trees came from stocks brought from Massachusetts. In 1879 the statement was made* that the knots were appearing

* *The Country Gentleman*, vol. 44, p. 262.

about Cincinnati in regions which had previously been free from the disease. Other cases of a similar nature might be mentioned, and although the disease may have been native to a large area, it appears to have attracted attention only after the cultivated plants upon which it thrives had been generally grown, and the conditions for its rapid dissemination had become favorable. At present the disease is confined to North America, no case of its occurrence in Europe or foreign countries having been reported. It is found throughout the United States, but is rare in the extreme south.

Description.—The superficial characters of the parts attacked by this disease are familiar to nearly every one who is in any degree interested in the extermination of the pest. The term "black knot" is very expressive, for the affected parts swell and present the form of more or less elongated knots which turn a deep black during the fall and winter. According to Humphrey* the newly forming knot can often be seen in the fall. It then appears "as a slight swelling of the branch, arising near an old knot, or independently." It is generally in the spring, however, that the knots can first be plainly seen. Affected portions commence to swell as soon as the active flow of sap begins, and as the swelling increases the bark is ruptured and a granular growth soon fills the crevices. This newly formed substance is light yellowish brown in color, and a tinge of green can sometimes be seen. The brown shade deepens as the season advances. During the latter part of May and early in June the swellings have enlarged to such an extent that they are frequently three to four times the diameter of the twigs upon which they are found. The bark very soon disappears, and the knot is found to be composed of a mass "in which all distinction between wood and bark has been lost. In the knot we find bast fibres, wood cells, and dotted ducts; but the prevailing tissue consists of a collection of dotted, rectangular, parenchymatous cells, with very thick walls which closely resemble the walls of the medullary rays."† The knot also gradually

*Eighth Annual Report of the Mass. State Agric. Exp. Station, p. 205.

†Farlow, Bull. of the Bussey Institution, Harvard University. Part V. p. 446.

changes color; and eventually it is perfectly black and presents the appearance which is so commonly seen, Figs. 3 and 4.

There is much variation in the size, shape, and location of the knots. Sometimes they do not grow to be more than a quarter of an inch in length, and then they do no particular damage. Such small knots are seldom seen, for their growth in spring is generally quite rapid and they frequently extend several inches along a twig. The largest knot which has come to my notice was on Morello cherries and was nearly five inches in length, it being all one year's growth. If the growth of other years is considered, the diseased portion will be considerably extended. It is a peculiar circumstance that the knots as a rule do not encircle a branch, but nearly all extend along the branch upon one side while the portion opposite remains healthy and permits the passage of the sap to the living portions beyond. Small twigs are frequently killed outright, for in them the disease soon cuts off all communication between the parts above and those below the affected portion. Large limbs do not succumb so rapidly. The disease gradually extends from year to year and it may be a long time before the death of the parts beyond takes place, for such, with probably rare exceptions, is the result which eventually follows the appearance of the trouble.

The form of the knots varies considerably. Upon the smaller branches, those two or three years of age, they are generally straight, or nearly so. The swelling is often more marked at the center of the diseased portion, and gradually diminishes towards the ends; but the swelling may have nearly the same diameter throughout its length, and in such cases the knot terminates abruptly. If the twigs are but a year or two old the presence of the knot may cause considerable bending of the wood, so that frequently the knot turns at a sharp angle, or it may be inclined to the form of a spiral. Large branches which cannot be affected in this manner generally cause the formation of knots that are more or less oval in outline, the most protruding portion being near the center. When the knots are formed in the forks of two branches, as so frequently occurs, they extend along both branches beyond the point of union, and also downwards. Such knots vary greatly in form.

The large majority of the knots found upon Morello cherries seem to form in the following places: in the crotches of younger limbs, at the union of the consecutive growths of two seasons, and upon small spurs which commonly bear the fruits. I have seen some the cases in which it appeared as if entrance had been gained in the axil of a leaf, or about the bud situated at its base. The swellings frequently form in the crotches of limbs that sometimes are four or five years old, but younger branches suffer to a very great extent. The knots which form at the union of the growth of different seasons may generally be found upon wood that is from one to three years of age. The center of the swelling is, as a rule, near the point of union. (See also page 646.) I have as yet failed to find in autumn or winter a well developed knot which was formed upon the growth made during the preceding spring and summer. They have invariably appeared upon older wood, and generally in the positions mentioned above. (See Fig. 3 page 645.)

During May and June the newly formed knots are covered with a velvety growth, but this soon disappears. The knot then becomes dark and by winter has become perfectly black. It is then covered by innumerable, small elevations which project from its irregular granular surface. At this season the knot is generally hollowed out by insects which have developed within, and so there is often not much more than a mere crust remaining. During the fall and early winter many of the knots become more or less coated with a substance which is yellowish white, and other colors may also be seen. This appearance is not a development of the knots, but is caused by a fungus which is parasitic upon them.

Cause.—It is only in recent years that the true cause of the black knot has been demonstrated. Formerly the trouble was generally supposed to be due to the work of insects, and this opinion is still held by many, although scientists have shown plainly that insects are not responsible for such swellings. Other theories were also freely advanced, such as a diseased condition of the sap, abnormal condition of the plant's "constitution," the character of the soil in which the trees were growing, and some form of mechanical injury. But such ideas were not so commonly accepted.

Black knots are now known to be brought on by a fungus, *Plowrightia morbosa*. It was long suspected that such is the case, for the fungus was imperfectly described by Schweinitz as early as 1821.* But the first published statement that the black-knot is caused by a fungus appears to have been made by Dr. Joel Burnett, of Southboro, Mass., although no proof of the proposition was given.† It was based upon the fact that the curculio, which is a regular inhabitant of the knots, did not lay its egg in them until the latter had formed, and thus it could not be held as the cause of the first appearance of the swellings. It was not until 1876 that the relation between the knots and the fungus was clearly shown.‡ Dr. W. G. Farlow then removed all doubt as to the cause of the disease, and although the entire life history of the fungus is not described, no further question can be raised as to the origin of the trouble. The following plants also seem to suffer from this disease: Chickasaw plum (*Prunus angustifolia*), beach plum (*P. maritima*), native red or yellow plum (*P. Americana*), choke cherry (*P. Virginiana*), wild black cherry (*P. serotina*), wild red cherry (*P. Pennsylvanica*). The sweet cherries (*P. Avium*) are said to suffer occasionally, but no authenticated case seems to be on record.§

The life history of the fungus as now understood is in brief as follows:|| The first external appearance of the disease is an enlargement which may be visible in autumn but is most marked in early spring. This swelling is caused by the irritation of the fungus which has entered the cambium layer of the branch. This layer is the one from which the inner bark and the wood are formed, and the presence of the fungus causes an abnormal growth to take place (see page 638). The first crop of spores are matured in May and June, and it is these and the threads bearing them which give to the knots the velvet coating they possess at this time of the year. The spores mature quickly and they are then scattered

* Synopsis Fungorum Carolinæ superioris, No. 134.

† *New England Farmer*, August 16, 1843.

‡ Harvard University Bulletin, Bussey Institution, Part V., 1876, p. 440.

§ I once collected knots from a tree of *Prunus Avium* in southern Delaware. The tree, which was of the mazzard or wilding type, was a foot or more in diameter of trunk, and the small limbs bore very numerous well developed knots.—L. H. BAILEY.

|| A list of the most important papers relating to the black knot disease may be found on page 636.

by various natural agencies. The knot then assumes a darker color and presents its characteristic hard, almost metallic appearance.

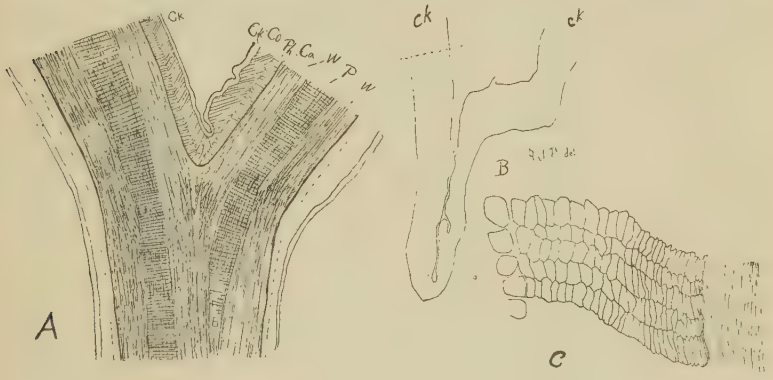
Another crop of spores is still to be borne before the knot has finished its work. These spores are formed in the small pimple-shaped elevations which appear on the surface of the knots in autumn and winter. They mature during midwinter or early spring, the time appearing to vary in different localities. As soon as they have ripened they leave the minute elevations in which they were formed, and are scattered to propagate the parasite in some other spot. The central portion of the knot has then finished its round of existence, but the outer portions continue to grow and form new knots above and below the old one. In this manner a single knot may in time extend a long distance on a branch.

Many points regarding the development of the black knot fungus are still imperfectly known. Two of the more important of these are the time and the manner in which the spores succeed in gaining an entrance into the host plant.

At present it can only be assumed that the spores germinate and penetrate the tissues soon after becoming ripe. The principal periods of infection would then be early spring, as soon as vegetation begins, or even earlier ; the other period would be from the middle of May to the middle of July, the time varying with the character of the season and with the locality. This subject is of the greatest importance when considered in its relation to the most favorable times for making applications designed to prevent the entrance of the fungus into healthy tissues.

From the fact that new knots show the first external indications of their presence only to a very limited extent in the fall, while the great majority of them do not form until spring, it would seem that infection takes place one year, but the knot does not develop until the following season. The manner in which the spores that mature in winter invest healthy tissues is not clear. There may be some relation between them and the formation of knots upon older wood, but the production of the spores in summer prevents the making of any definite statements which are not based upon careful artificial inoculations. As already stated, a great many knots are found in the forks of young branches, Fig. 3, 1, and at

the places in which one year's growth stopped and that of the following year began, Fig. 3. 2. A careful examintion of the forks of the small limbs shows that the union of the two parts is not so close as at first appears. The cellular structure of these parts, as revealed by the microscope, is seen to be such that the spore of a fungus would apparently have less difficulty in gaining an entrance here than in almost any other place. Figure 1, A, represents a section made at the union of two twigs. The different parts of the limb are here shown so that their relative positions may be understood. The outer layer *c k* is composed of cork cells. These are penetrated with difficulty by the threads from a germinating spore, and it may be that entrance is entirely prevented by them. The layer lying under the one composed of cork cells is the cortex, *c o*. This layer as a rule contains no cells which are lignified, or woody, but is composed of cells which are easily penetrated by the mycelium of many fungi. Underneath the cortex is a layer known as the



1.—*Crotch of branches where knots often form.*

phloem. The phloem comprises the hard and the soft bast cells, only the former being woody. The soft bast cells can also be penetrated by the threads of the mycelium and offer no obstacle to the passage of such parasites. In this manner a fungus can penetrate without much difficulty to the cambium layer, *c a*, represented only by a dark line, when once the layer of cork cells has been passed; for the woody or lignified cells are arranged in isolated bundles so that they do not interfere with the inward growth of the threads of the mycelium, or vegetative portion of the fungus.

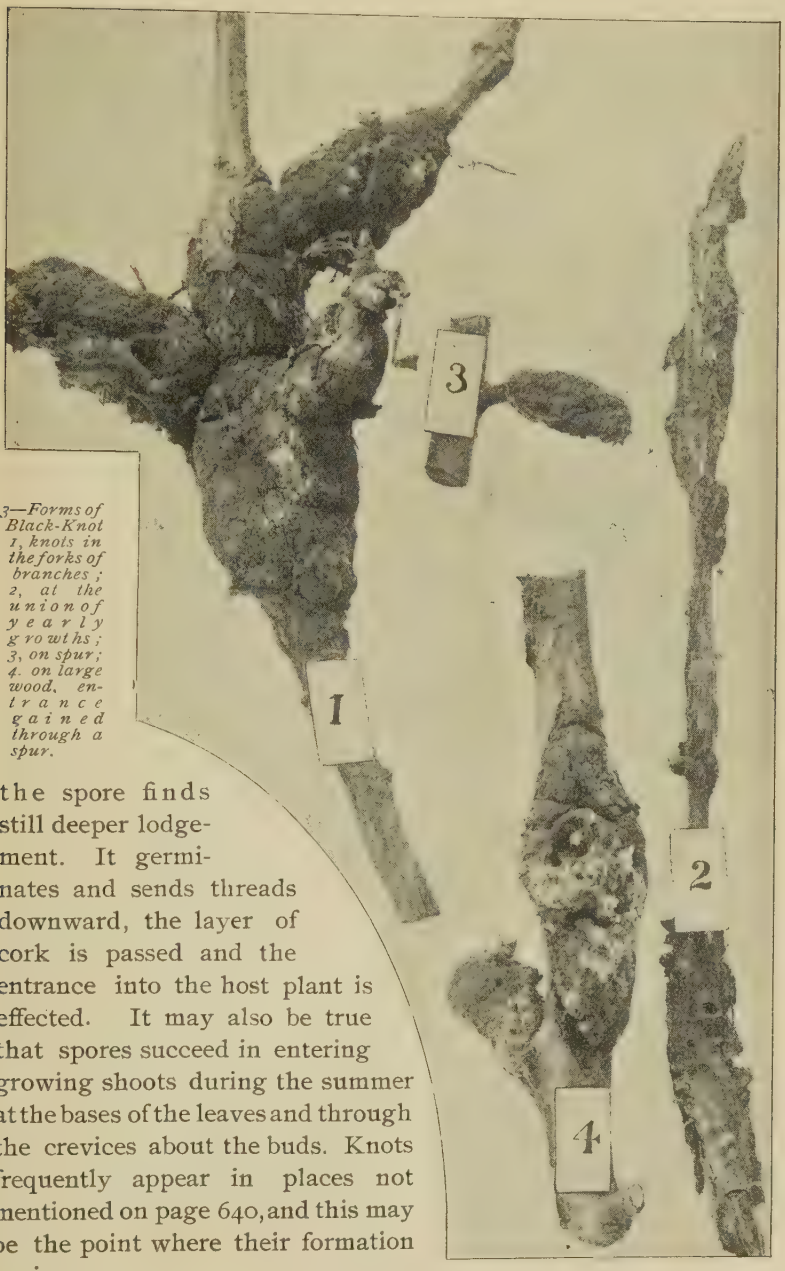
Diagram B of Fig. 1 represents only the layer of cork, more high-

ly magnified, as found in the crotch of two small limbs. It will be noticed how deep is the crevice which extends downward from the point at which the two parts are apparently united. Another interesting feature of the diagram is the variable thickness of the layer. Where fully exposed to the air it is comparatively thick, but within the crevice it is much thinner, especially so in a few places. Diagram C shows the layer magnified still more, a section having been taken at the point *c* in B. The center cells are flattened to such an extent that they cannot be plainly seen.

Figure 2 represents a highly magnified termination of another crotch taken from a Morello cherry tree the wood being two and three years old. The point *b* in this diagram corresponds with *b* in diagram B of Fig. 1; it is the lower extremity of the cork layer. But this fork shows a fissure which prolongs the crevice naturally made. The layer of cork cells has been separated, and an opening made into the cortex lying underneath. The cells surrounding the fissure were tested for corky tissue and also for lignin, or woody fibre. These two substances were found not to be present. The threads of mycelium would therefore have little trouble in gaining an entrance. The fissure seen below *b* was not a new one, for the cell walls surrounding it were darkened as by exposure to air, and it is probable that they exist quite commonly in the forks of Morello cherry twigs.

2.—*Lodgement for spores in a crotch.*

The manner in which the black-knot fungus gains an entrance into the forks of the smaller branches may thus be made fairly clear. A spore lodges in the crevice between the two branches; the action of the wind and the weight of the branches, especially when wet and bearing foliage, open the crevice more or less and



3—Forms of Black-Knot 1, knots in the forks of branches; 2, at the union of yearly growths; 3, on spur; 4, on large wood, entrance gained through a spur.

the spore finds still deeper lodgement. It germinates and sends threads downward, the layer of cork is passed and the entrance into the host plant is effected. It may also be true that spores succeed in entering growing shoots during the summer at the bases of the leaves and through the crevices about the buds. Knots frequently appear in places not mentioned on page 640, and this may be the point where their formation begins.

Number 2 in Fig. 3 shows two knots, each at the end of the growth of a season. The small lines running across the twig at the point of union of the parts formed in different seasons represent elevations and depressions in the surface. These would also afford protection and moisture to any spores which might lodge there. A microscopic examination shows also some very thin layers of bark, and it seems probable that an entrance could be affected here without much difficulty, provided atmospheric conditions are favorable.

4.—*Knot upon a large branch.*

Number 3 of the same illustration represents what may be considered as an explanation of the appearance of knots upon older branches (Fig. 4), or even upon the trunks of the trees. There can still be seen the remnants of small spurs which were probably first attacked. From these spurs the fungus entered the cambium layers of the larger portion, and thus the knot formed, and the part appears to have been directly attacked, although entrance in reality was gained through the spur, as is shown in No. 4 of the same figure.

These examples and many others of a similar character indicate that it is only comparatively young wood that is affected, the covering of the larger branches being so thick that it can withstand the attacks of the disease.

Remedies.—Although the black-knot fungus has been troublesome almost from the time that the stone fruits which it attacks have been grown in this country, no remedy has yet been found

to be of value. The earlier literature upon the subject contains considerable advice regarding the treatment of the disease, but as its nature was not understood such remedies were founded mostly upon an unreliable basis. For example, it was recommended to dig about the base of the trees in the fall, and to keep chickens; the use of two or more quarts of salt per tree was considered of value; pulverized blacksmith's cinders scattered about the base of the trees prevented the disease; iron filings or scraps of old iron answered the same purpose; much importance was also attached to the nature and drainage of the soil in which the trees were growing. This list by no means includes all the suggestions made.

The preventive measure of cutting out the knots as fast as they appeared was strongly recommended from the earliest time, and this is still one of our best methods, if not the best, of checking the spread of this pest. The best time to do the work is in early spring when the new knots can be seen. This prevents the production of both crops of spores and will undoubtedly soon rid a neighborhood of the disease if the work is properly done. The next best time is in the fall, before the second crop of spores have matured. If the work is postponed until after these spores have been distributed the value of the operation will be almost entirely lost. From two to three inches of apparently sound wood should be cut away below the knot in order that no part of the fungus will remain in the portion left upon the tree. It has been generally advised to cover the cut surfaces with some material to prevent further infection at this point. Shellac, paint, and a solution of copper sulphate have been recommended for the purpose, but the value of the practice has not yet been determined and the labor of covering such surfaces may be very great. When the knots have been removed they should be buried or burned, so that no spores may mature after the operation, as sometimes occurs when the knots are left lying upon the ground. One individual cannot exterminate the fungus in a locality, and if no laws exist demanding the destruction of the knots, public sentiment should be brought to the point of making such demands. Laws framed for the purpose of controlling the black knot now exist in Michigan,

New Jersey, New York, and Ohio.* California possesses laws aimed to keep all contagious plant diseases out of the state by means of the inspection of all imported stock; Ontario and British Columbia also possess laws designed for the better prevention of certain diseases of plants. If existing laws were enforced the extent of injury from the black knot fungus would be very greatly diminished. Unfortunately the above measures have not in all cases been as effectual as was hoped, and individual efforts are still required to free a locality from the pest.

The black-knot fungus may be destroyed while upon the tree, but the operation is tedious. The knots are painted with some liquid which will penetrate their interior, or form a coating over them which excludes the air. As early as 1855 spirits of turpentine† was used for this purpose. Kerosene was used in the same manner ten or fifteen years later, and linseed oil has been tried with apparent success. Kerosene and turpentine must be used with caution, for if a heavy application is made the branch beyond the diseased point will be destroyed and I have seen young plum trees killed outright by a too free use of kerosene. Linseed oil can be used with safety. It is advisable to use some coloring matter, as the red oxide of iron or white lead, to show what parts have been well covered. But the best way of disposing of the knots is to cut them out and burn them.

Since the discovery of the fungicidal properties of some of the copper compounds the remedies which are effective in controlling other fungous diseases have, to a limited extent, been recommended for the prevention of black knot. Very few, however, seem to have tried the experiment. The only recorded case which I have found is that of Maynard.‡ Certain plum trees were sprayed April 19 with a solution made by dissolving one pound of copper sulphate in twenty-two gallons of water. May 19 the application was repeated, but Paris green was added at the rate of one pound to five hundred gallons of the solution. This injured the foliage severely, so the Bordeaux mixture was used for later treatments which were made May 21 and 29, June 7 and 17, July

* A copy of the New York law may be found on page 392, Bulletin 75 of this station.

† *The Country Gentleman*, 1855, p. 106.

‡ Mass. Hatch Agric. Exp. Sta. Bull. 11, Jan. 1891, p. 19.

19 and 29. The conclusion reached was that "the number of warts was *very decidedly* less where treated with the copper mixture, than where untreated * * * and we believe that the plum wart may be held in check by this remedy."

In the spring of 1893 some experiments were begun with the intention of carrying on the work at least two seasons. A thicket of Morello cherry trees and sprouts was chosen for one field of operations. The plants were well covered with knots at the time, and these were all allowed to remain until the following year. The piece was divided into two nearly equal parts by cutting out the brush across a convenient portion of the strip. One part was treated and the other was not. The only fungicide used was the Bordeaux mixture. This was applied in 1893 upon the following days: March 29, April 18, May 6 and 30, and June 13. The trees were as well covered as could be done, but some of the parts were difficult of access.

The work was continued in 1894, and after one application had been made all the knots were cut out. This was done April 25, and the knots from each portion were counted so that the relative number of branches in each portion could be estimated and a basis for comparison might be made when the knots should again be cut. They had been allowed to remain on the tree during the preceding year so that the chances for further infection should be as favorable as possible. At the time of their removal no marked difference could be seen in favor of either portion as regards the relative abundance of the knots, although on the sprayed portion they may not have been quite so thick.

The Bordeaux mixture was again used in 1894. It was applied to the same portion treated in 1893 and upon the following dates: April 9 and 25, May 21, June 6 and 27, July 10 and 20, and August 1. This number of treatments gave the limbs and foliage a blue color which they retained until the leaves fell to the ground, and at this writing, December 3, the branches still show a decided coloration.

Figure 5 represents the thicket as it appeared November 26 before the knots were cut out after the summer's growth. The illustration does not represent plainly the number of knots present, but it will be noticed that there are many more on the unsprayed

5.—*Spraying for Black-Knot. Photograph taken in November, before the knots were cut The line A B marks the division of the plants. Left hand part untreated, the other sprayed with Bordeaux Mixture.*

6.—*Spraying for Black-Knot. The same as Fig. 5, after the knots were cut. Observe the severe pruning of the untreated part (to the left) as a consequence of the removal of the knots.*

than upon the sprayed part. The line between the two plots passes across the page from *A* to *B*. The knots were all cut out after the photograph was taken. The appearance of the thicket after the operation is shown in Figure 6. It will be noticed what a large proportion of small branches has been removed from the unsprayed part. When the value of these branches is considered, the seriousness of this loss can be realized. The sprayed portion lost but a very small number of such twigs and is still in very good condition. The table below shows the numbers obtained in the spring and those removed in the fall. By the term "new" knots are meant those which appeared to have been produced by a new infection; "old" knots are those which apparently grew from the mycelium which had not been removed when the knots were cut in the spring.

April 25, 1894.

Unsprayed portions, knots removed - - -	2002
Sprayed " " " - -	1155

November 26, 1894.

Unsprayed portion, total number removed 3529—new knots	3466
Sprayed " " " " 240 " "	165

The above figures are full of encouragement. They show, not that the black knot fungus has been held under absolute control, (and what fungous disease is,) but that it is susceptible to treatment. There was a large increase, nearly 57 per cent., in the number of knots cut in the fall from the unsprayed portion over those cut in the spring. Had the same proportionate increase taken place in the sprayed part, a supposition which must be allowed had no applications been made, the number of knots produced would have been within a fraction of 2000. Consequently, the 165 new knots should be compared with 2000, and not with 1155 as shown by the table. It must also be considered that this reduction took place in the face of circumstances which had been made as favorable for the spreading of disease as possible. The sprayed portion had been covered with knots during the first year's treatments. It was practically in contact with a large number of diseased plants. And finally, we are still in the dark as to the best time of making the application, for we do not know

with certainty when the infections take place, nor when the knot appears after infection has occurred. If this were known the matter would be considerably simplified, and still better results obtained. It would appear from the above that an orchard may be kept practically free from the knot if the trees are sprayed at the proper time. One or two treatments might be given before the blossoms open, and later applications probably need not be made oftener than is required to control the leaf-blight and the rotting of plums. If in addition to this the comparatively few knots which will undoubtedly appear be removed as soon as discovered, no grower need have much fear of this disease even though his trees be considerably exposed to infection from neighboring trees or thickets. The treatments which the above* experiment seems to justify me in recommending are as follows:

First. During the latter part of March or early in April.

Second. When the buds are beginning to swell.

Third. During the latter part of May, or as soon as the new knots begin to show their velvety coating.

Fourth. About two weeks after the third.

Fifth and Sixth. At intervals of two or three weeks after the fourth, but these two will probably not always be necessary.

The Bordeaux mixture may prove more valuable than other fungicides even in making the first applications, as it adheres better to the branches. It is probable that some of the above treatments may in time be dispensed with. Much will depend upon the season and upon the degree of infection to which the orchards are exposed.

It is scarcely necessary to add that all thickets, hedges, and useless trees which serve as breeding and distributing centers should be destroyed at the first opportunity. The species of Prunus mentioned on page 641 should be served in the same manner as useless cultivated plants, if they aid in the propagation of the fungus. In the end unceasing vigilance must bring its reward.

*It is unfortunate that other experiments begun at the same time and carried on in a manner similiar to the above have failed to give results from the fact that no new knots formed upon either the sprayed or the unsprayed portions. The plum orchard of Geo. T. Powell, Ghent, N. Y., has been under treatment during two years, as well as other trees in the vicinity of Ithaca. All have failed to develop new knots. But the work will be continued and it is hoped to make other reports in the future.

SUMMARY.

1. The black-knot of plums and cherries was first troublesome in the Atlantic states. Page 637.

2. Its presence west of the Alleghany mountains seems to be due at least in part to plants introduced from the eastern states. Page 637.

3. The first swelling of the knot occasionally begins in the fall but is generally first noticeable in the spring. Page 638.

4. The young, growing knot is yellowish brown in color, but this color changes to black as the season advances. Page 638.

5. Knots most commonly form in the forks of young branches, at the union of the growths of two seasons, and upon the small spurs which commonly bear the fruit. Page 640.

6. The cause of the black-knot is a fungus, *Plowrightia morbosa*. Page 641.

7. The fungus produces from each knot one crop of spores during the early part of the season, and another during midwinter, after which the central portion of the knot dies. Page 641.

8. Black-knots are very generally infested by insects, but these are not the cause of such swellings. Page 641.

9. The time in which the spores produced by the fungus gain an entrance into the branches is not definitely known, but it seems probable that this occurs soon after the ripening of the spores. Page 642.

10. The manner in which the spores penetrate the outer tissues has not yet been observed; but the fact that the layer of cork is thinnest, or entirely wanting, in those places in which the greater number of knots are found leads to the conclusion that the fungus can penetrate the outer tissues at these points, but cannot enter at all places. Pages 643, 644.

11. Knots found upon old wood first obtained a foothold upon younger wood, from which they spread to the older parts. Page 646.

12. Many remedies for the black knot have been suggested but none have proved to be efficient. Page 647.

13. The most generally recommended preventive measure is to cut out the knots and destroy them. This work should be

done as soon as the knot is observed, and if well carried out it is an excellent method of exterminating the disease. Page 647.

14. Since fungicides have come into use, spraying for the black-knot has been recommended. Page 648.

15. The conclusions drawn by Maynard from the experiments of one season recorded by him were that "the number of warts was *very decidedly* less where treated with the copper mixture, than where untreated. * * * and we believe that the plum wart may be held in check by this remedy." Page 649.

16. A thicket of Morello cherries which had been treated during two seasons by this station produced only 165 new knots. Page 652.

17. From another portion of the same thicket which had not been treated there were cut 2002 knots on April 25, 1894. On November 26 of the same year this portion yielded 3466 new knots, an increase of nearly 58 per cent. Page 652.

18. Had the sprayed portion remained untreated it may be supposed that a similar increase would have taken place in this part, making the assumed number cut within a fraction of 2000. Page 652.

19. The reduction of the number of knots from 2000 to 165, considering the present state of our knowledge, and the conditions under which the experiment was carried on, are encouraging, and point to a final control of the disease. Page 652.

20. Some of the applications which now appear necessary for the control of the black knot are to be made when other diseases require treatment. This necessitates but little extra labor in spraying for the prevention of the knots. Page 653.

21. The spraying of plums and cherries to protect them from the black-knot fungus, as stated on page 653, can be carried on with profit in all sections where this disease threatens to interfere seriously with the profitable cultivation of these fruits.

E. G. LODEMAN.

FORMULAS.

BORDEAUX MIXTURE.

Copper sulphate ..... 6 pounds
Quicklime ..... 4 "
Water ..... 40 gallons

Dissolve the copper sulphate by putting it in a bag of coarse cloth and hanging this in a vessel holding at least 4 gallons, so that it is just covered by the water. Use an earthen or *wooden vessel.* Slake the lime in an equal amount of water. Then mix the two and add enough water to make 40 gallons. It is then ready for immediate use. For rots, moulds, mildews. and all fungous diseases.

AMMONIACAL COPPER CARBONATE.

Copper carbonate ..... 1 ounce
Ammonia ..... enough to dissolve the copper
Water ..... 9 gallons

The copper carbonate is best dissolved in large bottles, where it will keep indefinitely, and it should be diluted with water as required. For same purpose as Bordeaux.

COPPER SULPHATE SOLUTION.

Copper Sulphate ..... 1 pound
Water ..... 15 gallons

Dissolve the copper sulphate in the water, when it is ready for use. *This should never be applied to foliage, but must be used before the buds break.* For peaches and nectarines use 24 gallons of water. For fungous diseases.

PARIS GREEN.

Paris green ..... 1 pound
Water ..... 250 gallons

If this mixture is to be used upon peach trees, 1 pound quicklime should be added. Repeated applications will injure most foliage, unless lime is added. *Paris green and bordeaux can be applied together with perfect safety.* The action of neither is weakened, and the Paris green loses all caustic properties. For insects which chew.

LONDON PURPLE.

This is used in the same proportion as Paris green, but as it is more caustic it should be applied with the lime, or with the Bordeaux mixture. Do not use it on peach or plum trees. For insects which chew.

HELLEBORE.

Fresh white hellebore ..... 1 ounce
Water ..... 3 gallons

Apply when thoroughly mixed. For insects which chew.

KEROSENE EMULSION.

Hard soap ..... ½ pound
Boiling water ..... 1 gallon
Kerosene ..... 2 gallons

Dissolve the soap in the water, add the kerosene, and churn with a pump for 5–10 minutes. Dilute 10 to 15 times before applying. For insects which suck, cabbage worms, and all insects which have soft bodies.